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PROJECT: PROJECT FIRE

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Scheduled to be launched no earlier than May 4, 1965.

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NASA SCHEDULES**PROJECT FIRE****LAUNCH IN MAY**

The National Aeronautics and Space Administration will launch from Cape Kennedy, Fla., no earlier than May 4 a second heavily-instrumented, 200-pound Project FIRE spacecraft on a 5,000 mile ballistic trajectory to expand scientific knowledge of reentry heating.

First of two FIRE flights took place from Cape Kennedy April 14, 1964, and was the fastest controlled in-flight reentry experiment ever conducted. The spacecraft reached a speed of more than 25,800 miles per hour and telemetered a large mass of important direct measurements of reentry heating.

Primary purpose of the second flight is to gather more data than the first experiment provided during the period of highest heating.

Project FIRE is managed by the Langley Research Center, Hampton, Virginia, under the general direction of NASA's Office of Advanced Research and Technology. Project FIRE has helped resolve some of the differences between various reentry heating theories and flight results have been used in the interpretation of research data resulting from laboratory experiments.

The reentry spacecraft to be flown in the second Project FIRE is a blunt-faced vehicle with a conical afterbody, similar in nearly all respects to the first reentry vehicle. Large amounts of laboratory data exist on similar shapes, and the blunt-face closely resembles the shapes of U.S. manned spacecraft on which information has been accumulated at lower reentry speeds.

The launch vehicle for Project FIRE will be an Atlas-D. A velocity package using the solid propellant Antares II rocket motor (also used as the third stage of the Scout launch vehicle) will add the speed needed to drive the reentry payload back into the atmosphere at 25,000 mph. The velocity package guidance system performed very accurately on the first FIRE flight and is similar to that used on the Scout.

The Project FIRE flight will follow a ballistic path along the Eastern Test Range with reentry near Ascension Island about 5,000 miles downrange in the South Atlantic Ocean.

Flight time will be about 32 minutes including a 21-minute coast period during which the spacecraft will be oriented to the correct entry attitude. Firing of the Antares II motor and spacecraft separation begin about 26 minutes after liftoff.

Instruments on the spacecraft, and telemetry receivers, radar and optical equipment ships and aircraft will gather data on the experiment.

Launch windows for Project FIRE are chosen to provide total darkness at 400,000 feet in the reentry area. On May 4, the launch window is between 5:14 and 11:29 p.m. EST. Windows exist for May 4 through 8 and again from May 21 through June 6. Clear weather in the reentry area is essential for optical observations.

(END OF NEWS RELEASE; TECHNICAL BACKGROUND FOLLOWS:)

Types of Reentry Heating

During reentry most of the speed (kinetic energy) of the reentering vehicle is changed to heat (thermal energy). Reentries at lunar and planetary return speeds generate significantly greater heat, and higher heating rates, than entries at orbital speeds.

At the speed Project FIRE will attain, the temperature of the gases in the shock wave area just ahead of the blunt reentry body will approach 20,000 degrees Fahrenheit. This temperature is an indication of the energy being transferred from the speeding vehicle into the surrounding air. The energy transferred is great enough to break diatomic gas molecules into individual atoms and to ionize many atoms.

Several chemical and physical changes then take place in the hot gas area just ahead of the reentering vehicle. Atoms may combine with atoms of a different element instead of their original diatomic twins. New gas components, not originally present, may be generated, and with them new physical characteristics.

At satellite reentry speeds and below, convective or friction heating is predominant. Convective heating takes place when heat passes directly from the air to the vehicle flying through it. It occurs in smaller amounts at all flight speeds in the atmosphere.

At higher speeds, radiative heating becomes more important. Unlike convective heating, radiative heating does not depend on direct contact, but is analogous to the heat emitted from the burning of an electric stove which can be felt several feet away.

Project FIRE was conceived by NASA as the major national effort to obtain first-hand scientific information on the magnitude of heating to be expected during 25,000 mph reentries. The first experiment provided the data over three important segments of the heating curve. Flight 2 will endeavor to define more completely the heating curve, particularly at the highest heating condition. This will have useful engineering applications in a variety of national programs and will increase the value of ground experiments and analyses.

Figure 1 (next page) shows the heating results obtained during FIRE I. The three periods during which data were obtained are shown as they occurred along the reentry path. The same three periods are shown on the graph as bands whose width represent the scatter of the telemetry records. In the next FIRE flight, the second measurement period will extend through the time of maximum heating.

Dotted lines on the graph indicate the disparity between theoretical heating estimates made before Flight 1 obtained direct data at speeds over 25,800 miles per hour. As a result of FIRE data now available, scientists are able to predict much more accurately, for engineering design purposes, the heating associated with entry into the Earth's atmosphere at speeds up to and beyond that of the Apollo command module on its return from lunar flights.

Project FIRE onboard experiments include direct measurements of radiation from the hot gas cap by means of specially developed radiometers. Temperatures will be measured by more than 250 thermocouples.

The phenomenon of radio "blackout" caused by the formation of a plasma sheath also will be studied. Reentry speeds produce large numbers of ions in the hot gas region ahead of the spacecraft and these ions carry electrical charges which block radio waves. Careful measurements of the way in which Project FIRE's telemetry transmissions vary through the re-entry phase are expected to furnish a better understanding of the plasma sheath communications problem.

PROJECT FIRE

LAUNCHED APRIL 14, 1964

TOTAL
HEATING

400,000 FT
25,000 MPH

FIRST
MEASUREMENT
PERIOD

SECOND
MEASUREMENT
PERIOD

LAST
MEASUREMENT
PERIOD

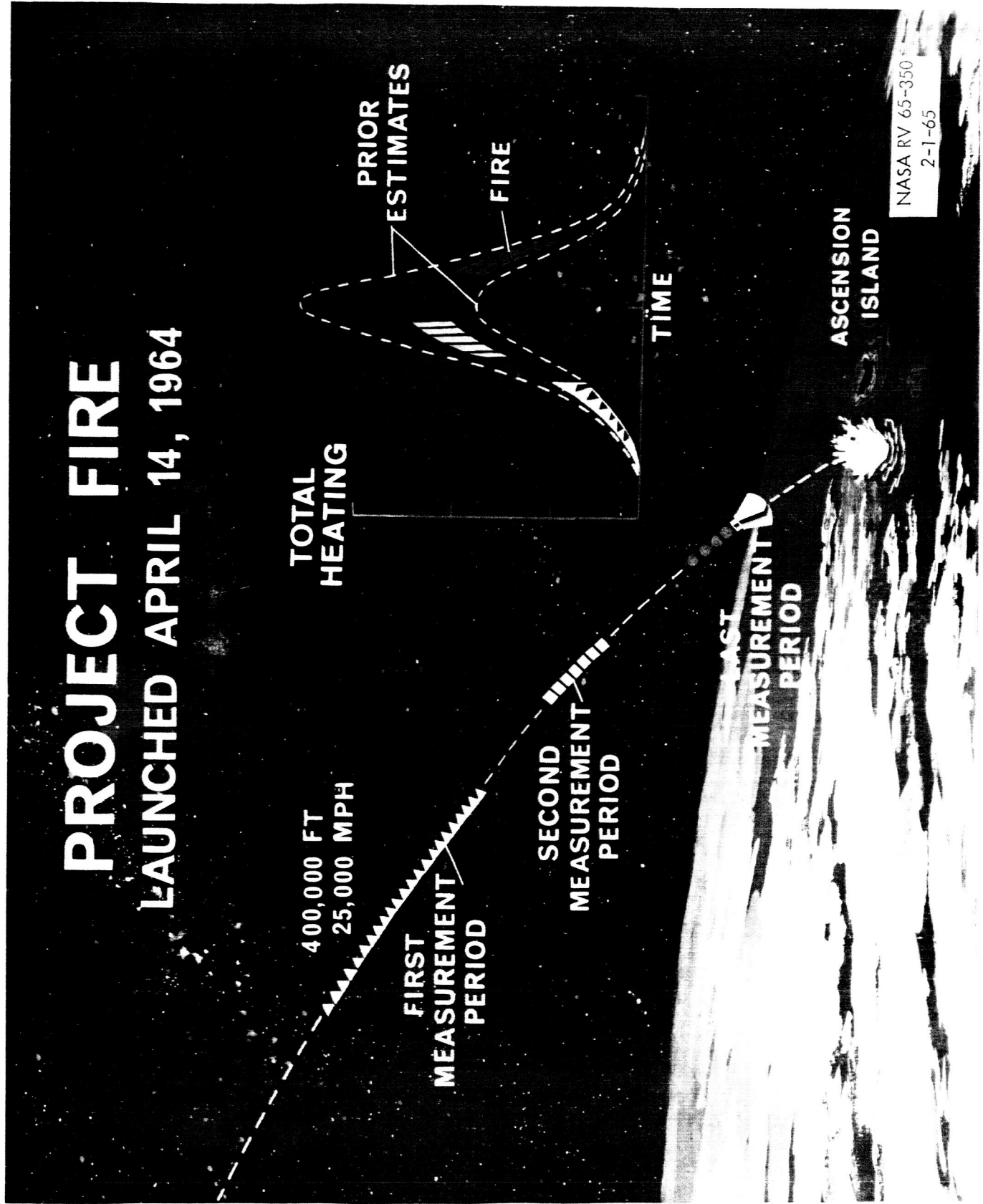
PRIOR
ESTIMATES

FIRE

TIME

ASCENSION
ISLAND

NASA RV 65-350
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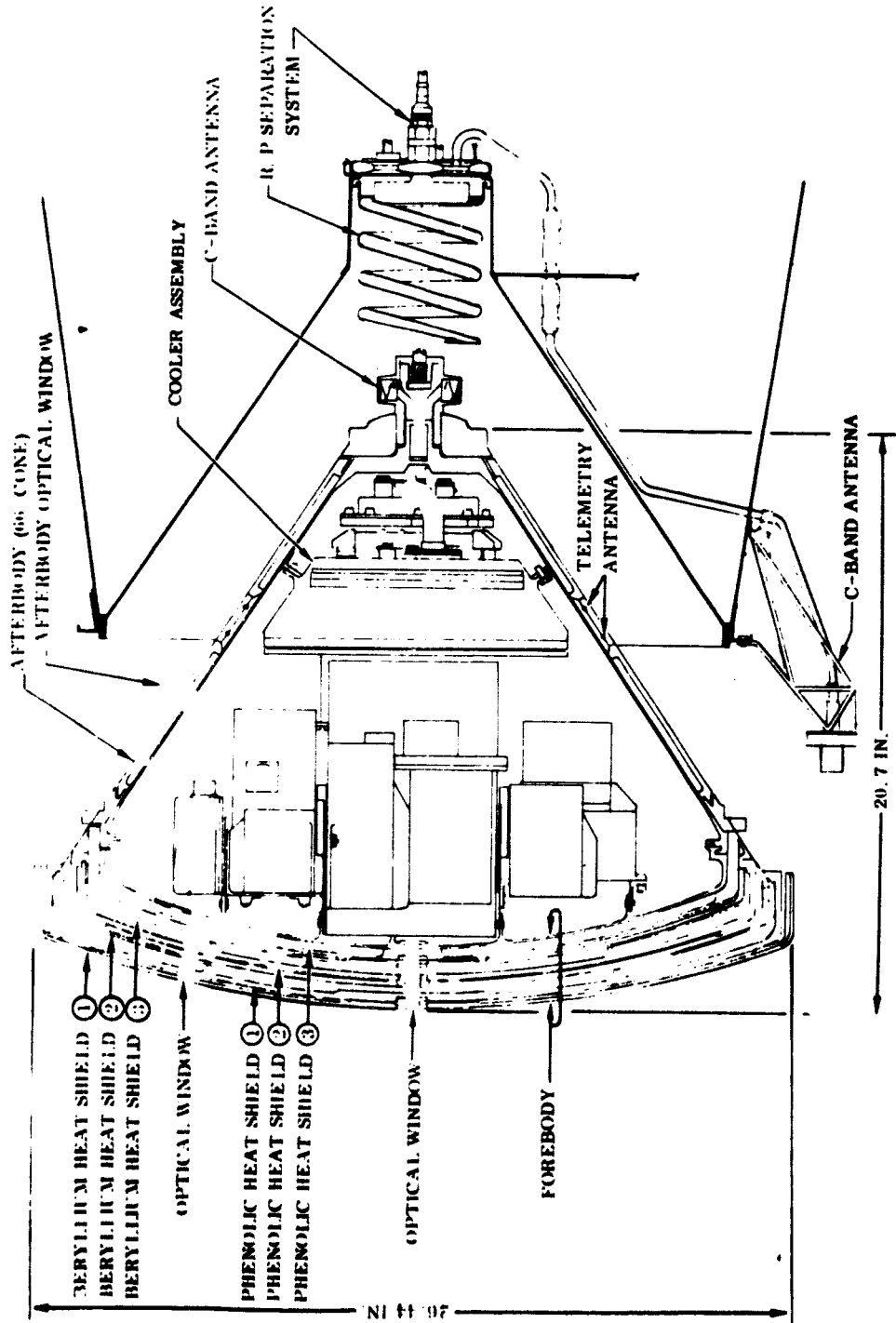
Project FIRE Reentry Package

The instrumented reentry package for Project FIRE is a blunt-faced vehicle with a conical afterbody, 26 inches in diameter across the face and 21 inches long. It weighs about 200 pounds. The adapter which supports the reentry package and connects it to the Antares rocket motor weighs an additional 75 pounds.

The blunt end of the reentry package consists of three beryllium calorimeters (devices for measuring absorbed heat) interleaved with three phenolic asbestos ablative heat protection layers. (See Figure 2, next page) The first, third and fifth layers are beryllium calorimeters instrumented with thermocouples to provide temperature readings from which the total heating rates will be determined. The second, fourth and sixth layers are heat shields. All but the last layer will be burned away or jettisoned during the 40-second flight through the high reentry heating period.

Choice of the layer design was dictated by the fact that the calorimeter material -- beryllium -- will survive only seconds of intense reentry heat. Hence a series of calorimeters will be used, one during the earliest portion of the reentry, one when heating rises to a peak, and the third near the end of the heating period. Two of the ablative heat protection layers will be jettisoned at programmed times to expose a fresh calorimeter to the hot gas region.

FIGURE 2



REENTRY PACKAGE.

Heat shield ejection times have been adjusted for the second flight to expose a fresh calorimeter at the period extending through maximum heating which was not completely covered in FIRE I.

Within the reentry package are three radiometers. Two are single devices to measure total radiant energy and the third is a combination total and spectral radiometer. They will furnish measurements of reentry heating due to radiation from the hot gases.

Radiant energy will be admitted to the instruments through fused quartz windows. One is located at the center of the forward face, in what scientists call the stagnation region; the second near the corner of the front face; and the third on the conical afterbody.

The combination total and spectral radiometer is designed to measure the radiant energy in such a way that the experimenters can gather information on the chemical composition of the gases in the radiant region. It will scan radiation at the stagnation point over a wavelength range from 3,000 to 6,000 Angstrom units.

On the basis of FIRE I experience, the radiometers have been provided with improved electronic circuitry. The changes have made the instruments easier to adjust and maintain at a stable operating level, and the accuracy and reliability of radiation measurements will be improved by the redesign.

- more -

In addition to these instruments, each of the ablative heat shield layers and a number of locations on the reentry package afterbody and interior structure are equipped with thermocouples, so that the complete spacecraft itself will operate as a calorimeter. All told, there are 258 thermocouples in the Project FIRE reentry package.

The conical afterbody is built of sheet aluminum and fiberglass, covered with a phenolic asbestos laminate. In addition to the primary instruments it contains: (1) data acquisition and processing electronics; (2) two solid-state telemetry transmitters; (3) a delayed data system which tape records research measurements during the 30-second radio blackout period for transmission after emergence from blackout; (4) a C-band beacon for radar tracking; (5) an attitude sensing system, consisting of three rate gyros and five linear accelerometers; (6) a pressure sensor; (7) an electronic device attached to the realtime telemetry transmitter to gather information on signal attenuation caused by the plasma sheath; (8) a time code generator to indicate elapsed time starting from liftoff; and (9) a cooling system.

Two subsystems in the reentry package have been modified since FIRE I. The attitude sensing system incorporates improved rate sensing gyroscopes and a special circuit has been provided to monitor their operation. A change in the telemetry system will provide a dual broadcast of the information stored in the onboard delay time recorder during the blackout period. On FIRE I, the delay recorder information was broadcast after blackout by a single channel. On the coming flight experiment, both the delay channel and the real time channel will carry the stored information starting about 40 seconds after the reentry package emerges from blackout.

The reentry package is not designed for recovery.

Velocity Package

The Project FIRE velocity package is designed to add sufficient velocity to bring the reentry payload to a speed of 25,000 miles per hour. It consists of an Antares II solid propellant motor which also is used as the third stage of the Scout launch vehicle. Its cylindrical filament-wound case is 30 inches in diameter. Antares II burns for about 30 seconds and produces 24,000 pounds of thrust at altitude. When assembled with the reentry package and adapter, it forms a structure 12 feet long.

At launch, the velocity package is connected to the Atlas launch vehicle by an adapter section 33 inches high. Around the base of the Antares there is a shell containing the subsystem devices required for guidance and attitude control, telemetry, ignition and destruction. The upper portion of the velocity package is protected during the launch phase of flight by a heat shroud. With the shroud in place, the velocity package assembly is 14 feet, four inches tall. Weight is approximately 4,000 pounds. Including the reentry package the total spacecraft weight is 4,200 pounds. The shroud, velocity package shell and attitude control system are jettisoned before the Antares II ignites. The weight at ignition will be 3,100 pounds.

The reentry package adapter for Project FIRE has been modified to carry a drag plate and an additional tumble rocket. This will increase the separation distance between the reentry package and the velocity package to simplify tracking.

Launch Vehicle

The Atlas launch vehicle is a "thick-skinned" version of the Atlas in that the skin of the forward conical section is somewhat thicker than normally and is similar to the Atlas vehicles used in the Mercury program.

NASA's Office of Space Science and Applications has overall launch vehicle responsibility for the FIRE mission.

The Lewis Research Center, Cleveland, Ohio, through its Agena Project Office, has technical management of the Atlas. Lewis is responsible for the launch vehicle requirements and follows through the procurement, design, fabrication, test, launch preparations and launch through injection of the velocity and reentry packages into the proper trajectory.

Atlas launches at the Eastern Test Range are directed by the Goddard Space Flight Center's Launch Operations. Lewis management responsibility ends at successful injection, but extends to post-flight data analysis and necessary recommendations concerning vehicle equipment.

At liftoff, the combination of the Atlas booster and the FIRE vehicle stand 84 feet tall and weigh about 270,000 pounds.

Atlas Booster Statistics

Thrust	360,000 pounds
Propellants	LOX and RP-1
Liftoff Weight	270,000 pounds
Liftoff Height	70 feet
Diameter	10 feet
Propulsion	Two Rocketdyne booster engines, one sustainer engine, two verniers
Major contractor	Convair division of General Dynamics, San Diego, Calif.
Guidance	General Electric radio inertial Burroughs computer

Mission Description

Project FIRE will follow a ballistic flight path of 32 minutes from liftoff to impact. Major events are clustered at the beginning and near the end of the flight separated by a 21-minute coasting period.

When Atlas lifts off with its two-ton payload, all five engines are firing (two boosters, one sustainer and two small verniers). The two booster engines are programmed to burn about half of the time of powered flight. When they shut down, the entire booster section will be jettisoned, and the sustainer engine will carry the booster through the rest of the powered flight. The verniers are the last Atlas engines to shut off -- about five minutes after lift-off.

The Atlas flies with a closed loop guidance. The vehicle's position and velocity are made available to the guidance computer ground station radar. Then, based on guidance equations, the computer determines actual event times. Thus, the time of any event in an Atlas flight is actually determined during flight.

When Atlas reaches desired acceleration the booster engines will be cut off (BECO) and, several seconds later, they will be jettisoned. The radio guidance system continues to determine velocity and issues appropriate commands to the Atlas. The sustainer engine continues to burn, carrying its now lighter load until the desired altitude and velocity are attained. It is then shut down (SECO) by radio command.

Following sustainer engine cutoff, the heat shroud will be jettisoned. During this time only the two verniers are still burning. The radio guidance then issues its last two commands -- vernier engine cutoff (VECO) and payload separation.

Spacecraft separation will take place after about five minutes of flight at an altitude of 190 miles, 490 miles downrange. A series of explosive nuts will be detonated to separate the velocity package from the launch vehicle, and retrorockets on the Atlas complete the separation.

Coasting flight begins with the velocity package under control of an inertially referenced attitude control and stabilization system. Six cold gas attitude control jets use nitrogen stored at 3,000 psi in four spherical tanks.

The velocity package will reach an apogee of approximately 500 statute miles about 2,440 miles downrange after 15 minutes of flight.

At the end of the 21 minute coast period, the reentry package is accelerated to the correct speed for the beginning of reentry.

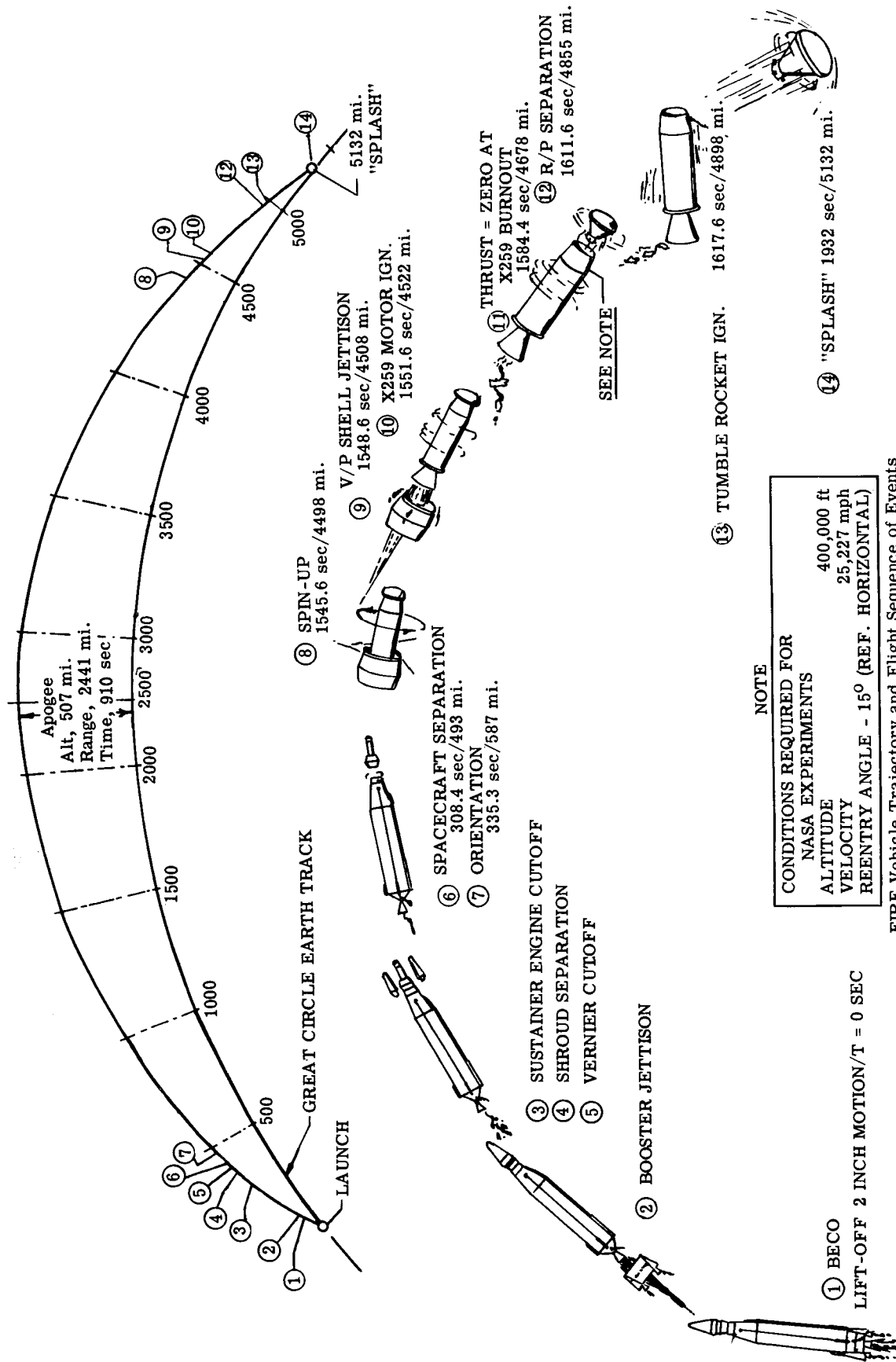
These events are as follows: (See Figure 3, next page)

1. Three spin rocket motors are ignited by a timer in the velocity package shell after 25 minutes and 45 seconds of flight. They impart a spinning motion to stabilize the flight of the velocity package.

2. Three seconds later, the velocity package shell is jettisoned.

3. Another three seconds later, the Antares motor is ignited and burns for about 30 seconds.

4. Spacecraft separation is scheduled after 26 minutes and 51 seconds of flight. At that point a pyrotechnic device releases a coil spring which expands to separate the reentry package from the adapter that remains attached to the Antares II. The reentry package moves away from the spent rocket case and adapter at six feet per second and after a six-second delay two small rockets fastened to the adapter are fired to insure positive separation.



At that time, the reentry package should be on a flight path inclined 15 degrees below horizontal, moving at 25,000 miles per hour on a south-easterly heading about 100 miles due west of Ascension Island. Splash is calculated to occur after 32 minutes and 12 seconds of flight at a point approximately 5,130 statute miles downrange.

Atmosphere Sounding Rockets

A Nike Apache sounding rocket will be launched from Ascension Island in the South Atlantic within an hour after the FIRE reentry package plunges back through the atmosphere at 25,000 mph. The sounding rocket program is managed by NASA's Goddard Space Flight Center, Greenbelt, Md.

Instruments carried in the 63-pound payload will measure density, temperature, pressure, and wind conditions up to 75 miles. The data will be telemetered to Ascension Island so NASA scientists can determine the atmospheric conditions through which the Project FIRE reentry package flew.

The University of Michigan, Ann Arbor, under NASA contract, designed the Nike Apache payload to be used in the Ascension Island tests. The New Mexico State University at University Park is responsible for tracking the payload.

Data and Tracking System

Telemetry from the reentry package, the velocity package and the launch vehicle will be received by ground facilities at Cape Kennedy. A range station at Antigua will obtain telemetry from the velocity package and the reentry package. At Ascension Island in the reentry area, reentry package and velocity package telemetry will be recorded. To collect telemetered data from the reentry package alone, aircraft and ship-borne receiving equipment will be deployed in the reentry area. All stations except the aircraft will provide either radar or optical tracking or both.

The tracking telespectrograph mounted on Ascension Island for the first Project FIRE flight has been modified mechanically and electronically to improve its data gathering capabilities. The trajectory planned for has been shortened by 100 miles to ease tracking requirements.

The telespectrograph combines the light-gathering power of a 36-inch diameter telescope with a conventional slitless spectrograph to obtain a spectrographic record of the reentry as it takes place some 80-160 miles from Ascension. The instrument is capable of measuring the spectrum of light generated during the Project FIRE reentry in the visible and near infrared wavelength range to define the chemical constituents of the incandescent gas. The recording spectrograph uses both film and lead sulphide detectors.

The instrument, weighing more than 22 tons, is capable of extreme pointing accuracy, rapid tracking ability and very high resolution of the optical information it will gather. It was developed under sponsorship of Langley.

The Project FIRE Team

Project FIRE is a research investigation of NASA's Office of Advanced Research and Technology, headed by Dr. Raymond L. Bisplinghoff. Project FIRE is a responsibility of the OART Space Vehicles Division, headed by Milton B. Ames, Jr.; Program Chief is Ralph W. May, Jr.; and Flight Project Officer is Ballard E. Quass.

Launch Vehicle and Propulsion Programs of NASA's Office of Space Science and Applications has overall launch vehicle responsibility for the mission. Joseph B. Mahon, Agena Program Manager, directs the FIRE launch vehicle program.

Langley Research Center, Hampton, Virginia, headed by Dr. Floyd L. Thompson, Director, is responsible for managing Project FIRE. The Flight Reentry Programs Office, under David G. Stone, Manager, executes Langley's management functions. His principal assistants are Richard C. Dingeldein, in charge of the Mission Technical Office; I.G. Recant, head of the Supporting Programs Office; H.F. Weber, responsible for Spacecraft

Systems; L.E. Williams, responsible for the Velocity Package; T.S. Williams, responsible for the Reentry Package; D.H. Ward, in charge of Operations; and J.E. Canady, head of the Space Vehicles Office. J.N. Daniel of Langley has responsibility for Tracking and Data Acquisition.

The launch vehicle system procurement and management is a responsibility of the NASA Lewis Research Center, Cleveland, Ohio. Dr. Seymour C. Himmel is Manager, Agena Project Office at Lewis and Richard C. Dillon is Agena project engineer for FIRE. The Atlas launch vehicle was procured through the Space Systems Division of the U.S. Air Force.

Launch operations responsibility has been delegated by the Lewis Research Center to the Goddard Space Flight Center's, Launch Operations, directed by Robert H. Gray.

NASA's John F. Kennedy Space Center is supporting the project in data handling, telemetry, and logistics.

Republic Aviation Corporation, Farmingdale, New York, was contractor for the reentry package.

The velocity package was built by Ling-Temco-Vought, Astronautics Division, Dallas, Texas.

The Antares II motor was produced by the Hercules Power Company, Wilmington, Delaware, and was procured through the Langley Research Center.

General Dynamics/Convair, San Diego, Calif., is prime contractor for the Atlas launch vehicle and, under a separate contract, furnishes services necessary to accomplish integration of all systems and subsystems involved in Project FIRE.

Extensive ground-based support for Project FIRE is provided by the Air Force Eastern Test Range.

On-board research data gathered during the course of Project FIRE is reduced by Republic Aviation Corp., under contract to NASA and subsequently analyzed by members of the scientific and engineering staff of the Langley Research Center.